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The Characteristics of Scientific Literacy-Based Teaching Materials for Developing Computational Thinking Skills

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Abstract. The development of scientific literacy-based teaching materials is part of the second phase of research and development (R & D). The purpose of this study is to describe the validity of developed teaching materials, to know the practicality test of teaching materials developed by a limited-scale trial, and how the characteristics of scientific literacy-based teaching materials develop computational thinking skills. The instruments used are test and questionnaire. Based on the data analysis, the results of this learning materials are assessed with valid criteria by 3 experts. The results of the test shows that the reliability gains r_{11} 0.739 or score of 82.5 to the practicality of the developed teaching materials based on its reliability with student response or scored.

Keywords: Teaching Materials, Scientific Literacy, Computational Thinking Skills

1. Introduction

The development of science and technology of the 21st century makes us always improve ourselves so as not to fall behind the flow of globalization. One of the key holders is education. Education becomes the center of critical and innovative thinking and action toward improvement. Even in college, education brings forth to students as pioneers and agent of change. One of the competences that must be developed in the education process according to Bruner and Connel is the skill of thinking [1]. Therefore, human should be equipped with thinking skills to face any problem. Thus, in order not to be left behind in the global world, Indonesian people should have qualified competence and skill.

One of skills and competences that should be possessed by human are scientific literacy and computational thinking (CT). Computational thinking (CT) is being located at the focus of educational innovation, as a set of problem-solving skills that must be acquired by the new generations of students to thrive in a digital world full of objects driven by software [2]. This fact is reflected in the recently released Next Generation Science Standards and the decision to include "computational thinking" as a core scientific practice [3]. The competence of scientific literacy deals with one's ability to understand and implement science in daily life [4], while CT is a man's ability to engage various thought of processes to solve complex problems [5]. Computational thinking is a pattern built in solving problems by integrating ideas, data, logic with various disciplines and thoughts like computer operations [6]. Both skills are needed by students of Elementary School Teacher Education (PGSD) of Muria Kudus University (UMK) as the agent of change in developing innovation and new ideas. In addition, the growing issues in the global world state that CT as a skill and competence should be included in the school curriculum so that students could solve more complex problems as how computer works [7].

Students of PGSD UMK are anprospective elementary school (SD) teachers. They need CT skills because they are used to explain more complex problems using abstracts, models and simulations [8]. Piaget's development theory states that children in elementary are in their operational stage [9], so what they know is setto be the concept embedded in their mind because elementary students have not been able to think abstractly, in fact science is a concept that involves abstract thinking. Therefore, in order to be able to convey the concept of science to elementary students, students of PGSD must have the ability to automate, simulate and create a model that allows elementary students easily receive the science lessons. The competence is named Computational Thinking. Computational thinking (CT) has been described as a mental activity, a problem solving approach, and a skill fundamental to most disciplines [10].

Computational Thinking can be improved if the students have well scientific literacy competence. However, the results of Program for Economic Cooperation and Development (PISA-OECD) of 2015, Indonesian students' scientific literacy was on the order of 63 out of 70 participants [11]. Whereas according to the analysis of needs in real life situation, PGSD UMK students' scientific literacy is in nominal and functional level [12]. Thus, it could be concluded that Indonesian college students' scientific literacy, especially students of PGSD UMK is finite and need improvement. Based on the analysis of needs through questionnaire, one of the factors causing low level of student's literacy is the availability of teaching materials of science concept. The questionnaire results show that students need teaching materials which are able to perform the concept contextually, involving the ability to think and work in scientific inquiry involving various thinking skills. Teaching materials are an important component of learning [13].

Based on these problems, it is needed the development of teaching materials that contain the competence of scientific literacy which is integrated with the CT step so that students have well ability of scientific literacy and computational thinking. In order to make these teaching materials applicable for students' competence development, the analysis of needs are required to find the characteristics of developed teaching materials, to assess the validator and to test the teaching materials.

2. Method

This research aimed to describe the validation result of the development of scientific literacy-based teaching materials in developing the computational thinking skills of PGSD FKIP UMK students, and to test the practicality of teaching materials through a limited-scale trial. This research was a second phase research in sequence of study of research and development (R&D). The research technique used was quantitative descriptive. Population in this research was student in second semester, with 20 students as the sample of research. The instrument used in this research was validation sheet given to three validators to know the validity of teaching materials and test instruments; and questionnaires to know the practice of teaching materials given to PGSD students in 2nd semester through a limited scale test.

3. Result and Analysis

This research and development included the stage of preliminary study, development and the validation. This paper presented the results of the development stage of scientific literacy-based teaching materials to develop students' computational thinking (CT) skills. This stage of development includes the analysis of needs; learning achievement of science concept courses; the making of teaching materials; expert validation; evaluation and improvement; limited scale test; and results evaluation of limited scale test.

3.1 Characteristics of the teaching materials

The making of teaching materials started with the analysis of potentials and problems through literary and studies. Based on the analysis of needs, scientific literacy of PGSD UMK students was 66, 2% in nominal level and 33.8% in functional level [12]. After identifying the problem, the researcher subsequently arranged the teaching materials that started with the analysis of learning achievement. The researcher reconstructed the course of science concept by rearranging the Learning Implementation Plan (RPS). The

evaluation and construction of learning resources should be holistic and sustainable in order to make better learning [14]. After that, the researchers arranged teaching materials of science concepts subjects thematically, meaning researchers determined a major theme but it contained the material of biology, physics and chemistry. The thematic-themed lesson would make students fully understand the concept so as to influence the meaningfulness of the concept [15].

Based on existing analysis of needs and problems, the developed teaching materials were containing scientific literacy and computational thinking competences. The scientific literacy competence was important because science orientation was one of the goals of 21st century science education [16]. Meanwhile computational thinking competence was a new literacy capability of 21st mid-century [5]. Both competencies were needed in solving complex problems. There were even some abstract and complex issues that could not be solved with critical or creative thinking skills but it needed to involve CT competencies since CT competence involved a lot of thinking skills [17]. In addition, based on the analysis of needs in real life situation, PGSD UMK students did not have well scientific literacy skills. Therefore, it took the teaching materials that contain the scientific literacy competence in order to develop the competence of Computational Thinking.

Result of the discussion between researcher and validator based on the analysis of needs in field and literature showed that the developed material was the material that contained scientific literacy and computational thinking competences. The material consisted of cover, table of contents, preface, manual of using material, purpose of study, maps of concept, science-based literacy phenomena (application and science context) as a warming up, science-based investigation, science-based content materials, thinking activities in solving problems correspond to CT flow, summary, tasks, glossary, evaluation and bibliography. The surplus of this developed material was integration between science literacy and CT competences. Students was provided various scientific phenomena which contain competence of scientific literacy such as content aspect, competence and context of science which contain complex issues, those was analysed in correspond to CT flows

The CT flows consisted of analysing and finding data; ideas and facts from scientific phenomenon; describing issues into specific parts; making abstraction by reducing issue complexity to be main topic; finding the pattern of problem solving; making algorithm by deciding the systematic troubleshooting steps; automating the right steps; presenting the used steps by simulation and conclusion [5]. Therefore, the developed material was not in form of full-text, but presenting the science phenomenon in society that should be studied and completed by questions in order to lead students to find the learning concept by themselves. This statement was in line with Bower et al [18] opinion that the ability of CT could be improved by prospective teacher through professional learning, like student-centred learning by finding the concept by their own ability. The appearance of teaching materials can be seen in the following picture 1 and picture 2 .


keuntungan mekanik untuk menggandakan gaya. Dengan mengabaikan gaya gesek yang timbul, maka kerja yang dilakukan oleh beban besarnya akan sama dengan kerja yang dilakukan pada beban. Kerja yang timbul adalah hasil gaya dan jarak. Jumlah kerja yang dibutuhkan untuk mencapai sesuatu bersifat konstan, walaupun demikian jumlah gaya yang dibutuhkan untuk mencapai hal ini dapat dikurangi dengan menerapkan gaya yang lebih sedikit terhadap jarak yang lebih jauh. Dengan kata lain, peningkatan jarak akan mengurangi gaya yang dibutuhkan. Rasio antara gaya yang diberikan dengan gaya yang dihasilkan disebut keuntungan mekanik. Ada berbagai jenis pesawat sederhan diantaranya tuas, bidang miring, roda berporos katrol, sekrup dan lain sebagainya. Seiring dengan perkembangan zaman yang semakin modern terdapat berbagai macam alat yang dapat membantu dan memudahkan pekerjaan manusia, diantaranya crane.

Gb 35. Pesawat sederhana jenis katrol
sumber: wikipedia.org

Gb 36. Pesawat sederhana jenis tuas

CONTOH SOAL (alur berpikir CT)

1. Apakah jenis skeleton yang ada pada invertebrata?
   Respons:
   (menemukan dan menganalisis data) Invertebrata merupakan hewan tidak bertulang belakang, diantaranya molusca, arthropoda, dan echinodermata.
   Solusi:
   (langkah pemecahan masalah dan menjelaskan) Hewan berbadan lunak seperti anemon laut dan cacing tanah memiliki skeleton hidrostatis yaitu cairan pembungkus tempat aksi otot yang berkontraksi. Beberapa molusca dan semua arthropoda mempunyai skeleton eksternal atau eksokleten. Echinodermata mempunyai skeleton internal atau endoskeleton.
2. Skeleton hidrostatis invertebrata bergantung pada sifat air yang mana?
   a) Tembus pandang d) semuanya benar

Picture 1. The main topic


POJOK LATIHAN (LS dan CT)

1. (menganalisis) Bagaimanakah bakteri, protista, dan fungi bergerak?
2. (mengidentifikasi) Apakah jenis rangka yang ada pada vertebrata?
3. (mengidentifikasi) Berapakah jumlah tulang pada rangka tengkorak, badan dan alat gerak? Sebutkan!
4. (menjelaskan) Bagaimanakah cara otot berinteraksi dengan tulang?
5. (memahami konsep) Apakah peran kalsium pada tulang dan otot?
6. (menjelaskan) Bagaimanakah caranya merawat tulang dan otot agar sehat dan kuat?
7. (alur berpikir CT) Apa sajakah jenis-jenis dari pesawat sederhana itu? Sebutkan disertai dengan penjelasan mengenai keuntungan mekanik yang diberikan!

FENOMENA LITERASI

Body Sixpack dengan mengkonsumsi suplemen

Hormon testosteron mempunyai efek metabolik. Hormon tersebut mendorong pembentukan protein sehinga dapat meningkatkan massa otot. Itulah yang menyebabkan kecenderungan pria lebih banyak berotot daripada wanita. Hal itu juga yang menjadikan alasan mengapa beberapa atlet binaraga dan atlet lain menggunakan steroid anabolik (turunan sintetik testosteron) atau mengkonsumsi suplemen untuk meningkatkan kadar tostesteron secara alami. Misalnya, atlet bola kasti, McGwire mengkonsumsi andro yang berhasil membuat catatan *home-run* pada musim tunggal liga baseball utama. Andro terbentuk secara alami dalm tubuh sebagai produk intermediet pembentukan hormon seks testosteron. Apakah dengan minum andro sebagai suplemen diet dapat meningkatkan penmpilan atlet? Andro sebagai steroid anabolik, memiliki efek samping. Suplemen tersebut meningkatkan kadar hormon wanita estrogen pada pria yang dapat dibentuk dari andro. Estrogen memiliki efek feminin pada pria, termasuk penegcilan testis, pembentukan dada seperti wanita dan kehialangan rambut. Selain itu, andro dapat meningkatalcna resiko kerusakan hati dan

Picture 2.layout on the sub-phenomenon of literacy

3.2 Findings Material Validation

After obtaining the material design as needed, the material was validated by three validators to assess the content of the validation and the material properness. The used instrument was validation sheets which contained the component of content properness, language properness, presentation properness, sufficiency of scientific literacy component and sufficiency of CT competence. The recapitulation of material validation could be seen in Table 1.

Table 1. Recapitulation of Material Validation

No	Expert	Score				final score
		Properness component				
		content	language	presentation	literacy & CT	
1	Expert 1	90	92	86	89	89,25
2	Expert 2	89	91	93	88	90,25
3	Expert 3	92	93	90	92	91,75
	sum	270	276	269	269	271,25
	average	90,3	92	89,7	89,7	90,4
	categorized	excellently valid				

According to Table 1, it is known that average validation of material was 90,4 or categorized as excellently valid. Therefore, the material can be used by several inputs, i.e. design graphic and template of the picture, photos in the material should be original, pictures' size had to be balance, the writing of scientific terms and units should be reviewed, the information needed to be updated, and sentence construction needed to be reconsidered.

In addition to the reaction and input from validators, there were inputs from students, such as difficult foreign language which had not listed in glossaries, students' confusion in practicing, especially when using tools and equipment because they had not used to use them and lack of the availability of research-based laboratory in PGSD. The existing laboratory was natural science laboratory for elementary; it needed a additional time for practice because *3 sks* per meeting was not enough for practice and explaining material. After that, the material was improved based on suggestion from validators, especially the one that was related to inquiry and discovery activities by using simple laboratory. It happened

because the inquiry learning could develop scientific literacy ability [19]. In addition, CT oriented to inquiry learning was easy to make people solve their problems [20].

3.3 Limited-Scale Trial

After the material was validated as proper, the material was tried to be applied in limited-scale. The result of the limited scale trial was used to get information about the material practicality, applicability, readability, and its constraints in the use of the learning process.

The limited-scale trial was applied to 20 students in their second semester as the sample on movement theme. The movement theme contained movement material on living being, movement on things and movement effects to something. The limited-scale trial was given in four meeting, with *3 sks* per meeting. After the students were given the developed material, in the last meeting, they were given evaluation and questionnaire in order to know the materials' practicality.

In this limited-scale trial, firstly, students were given the material to be studied at home. In the early stage, students were asked to read the map concept and science context, based on their scientific implementation in daily life. After that, students were divided into five groups to do simple practice in finding the learning concept. The practice activity was aimed to sharpen the science competence aspects that was combined with CT competence.

After the practical work was done, students discussed about the given Computational thinking questions in form of problems or science phenomenon in society. The lecturer then gave reinforcement related to the learning material. After delivered all material, the final step was giving post-test to know the reliability and the level of difficulty level and question differentiator. Evaluation questions was given in the form of reason-based multiple choice in 40 questions. Besides, students were also given questionnaire toward given material and the learning lesson.

Based on question analysis, the reliability question was 0,739. The result then compared to r_{table} 0,423. Since $r_{counted} > r_{table}$, so it can be concluded that the question was reliable. Based on the difficulty level and question differentiator trick, it can be concluded that the questions was in good and acceptable category. In addition, practicality assessment of the material developed from students' questionnaire scored 82,5 or categorized as good . Therefore, based on a limited-scale test the developed material was proper to be used for research, but it still needed revision from validators' and students' input.

4. Conclusion

Based on the results of the analysis and discussion, it can be concluded that: (1) the characteristics of developed teaching materials should contained scientific literacy competence integrated to the flow of Computational Thinking, (2) based on the assessment of the three validators to know the teaching materials appropriateness, the validation result was 90.4 or categorized as excellently valid and appropriate to be used, (3) based on the results of a limited-scale test to know its practicality, the reliability test results was 0.739 or categorized as reliable, while based on the results of questionnaires of students'responses towards developed teaching materials, the score was 82.5 or categorized as good.

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6. References

[1] Pidarta, M. 2007. *Landasan Kependidikan*. Jakarta: Rineka Cipta.

[2] Gonzalez, R.M., Juan., C.P.G. & Carmen, J.F. (2017). Which cognitive abilities underlie computational thinking? Criterion validity of the Computational Thinking Test. *Computers in Human Behavior*, 72 (1): 678-691. Retrieved from: http://www.sciencedirect.com/science/article/pii/S0747563216306185.

[3] Weintrop, D., Elham, B., Michael, H., Kai, O., Kemi, J., Laura, T., Uri, W. (2016). Defining Computational Thinking for Mathematics and Science Classrooms. *Journal of Science Education and Technology*, 25(1): 127-147. Retrieved from: http://ccl.northwestern.edu/2014/Weintrop_et_al-NARST_2015.pdf

[4] Bybee, et al. 2009. PISA 2006: An Assessment of Scientific Literacy. *Journal of Research in Scince Teaching*, 46(8): 865-883.

[5] Wing, J., M. 2006. Computational Thinking. *Communication of the ACM*, 49(3): 33-35.

[6] Qualls, J., A. &Linda, B., S. 2010. Why Computational Thinking Should Be Integrated Into The Curriculum. *Journal of Computing Sciences in Colleges*, 25(5): 66-71.

[7] Liu, J., Lin, C. H., Hasson, E. P., & Barnett, Z. D. 2011. Introducing Computer Science to K-12 through a Summer Computing Workshop for Teachers. *In Proceedings of the 42nd ACM Technical Symposium on Computer Science Education*, pp. 389-39.

[8] Voskoglou, M & Sherly, B. Problem Solving and Computers in a Learning Environment. *Egyptian Computer Science Journal ECS,* 36(4): 45-46.

[9] Trianto. 2007. *Model-model Pembelajaran Inovatif Berorientasi Konstruktivistik.* Surabaya: Prestasi Pustaka.

[10] Good, J. Aman Y. & Punya. M. (2017). Computational Thinking in Computer Science Classrooms: Viewpoints from CS Educators. *Proceding Society for Information Technology & Teacher Education International Conference*, in Austin, TX, United States ISBN 978-1-939797-27-8 Publisher: Association for the Advancement of Computing in Education (AACE), Chesapeake, VA. Retrieved from: http://www.punyamishra.com/wp-content/uploads/2017/02/ComputationalThinkingandCSTeachers.Good_.Yadav_.Mishra.pdf.

[11] OECD. 2016. *PISA 2015 Results Excellence and Equity in Education Volume I*. Paris: OECD Publishing.

[12] Fakhriyah, F. S. Masfuah, M. Roysa, A. Rusilowati, E. S. Rahayu. 2017. Student's Science Literacy in the Aspect of Content Science?. *Indonesian Journal of Science Education*, 6(1): 81-87.

[13] Bauer. 2010. Textbooks and Teaching Resources: A Case Study from the Early Childhood Classroom-Australia. *IARTEM e-Journal*, 3(2): 81-96.

[14] Bundsgaard, J. & Hansen, t. I. 2011. Evaluation of Learning Materials: a Holistic Framework. *Journal of Learning Design*, 4(4): 31-44.

[15] Prastowo, A. 2013. *Pengembangan Bahan Ajar Tematik*. Jogjakarta: DIVA Press

[16] Hoolbrook & Rannikmae. 2009. The Meaning of Scientific Literacy. *International Journal of Environmental & Science Education,* 4(3): 275-288.

[17] Liu, J. & Wang, L. 2010. Computational Thinking in Discrete Mathematics, *IEEE 2nd International Workshop on Education Technology and Computer Science*, 413-416.

[18] Bower, M., Wood, L. N., Lai, J. W., Howe, C., Lister, R., Mason, R., Highfield, K., & Veal, J. 2017. Improving the Computational Thinking Pedagogical Capabilities of School Teachers. *Australian Journal of Teacher Education*, 42(3): 53-72.

[19] Gormally, et al. 2009. Effects of Inquiry Based Learning on Student's Science Literacy Skills and Confidence. *International Journal for the Scholarship of Teaching and Learning*, 3(2): 1-22.

[20] Gao, Qian. 2011. The Computational Thinking-Oriented Inquiry Teaching Mode for Advanced Programming Languange Course. *An Indian Journal BAIJ*, 10(12): 6287-95.

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